Measuring up to ICT Teaching and Learning Standards

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Abstract

In Australia, the Government has called for a national set of learning and teaching standards against which to regulate for quality assurance in the higher education sector. In 2010, eight discipline groups were sent out into the community; their task was to gather the threshold set of academic standards defining their profession. After a year of stakeholder consultations, the Engineering and Information and Communication Technology (ICT) group arrived at 5 threshold learning outcomes necessary for inclusion in ICT curricula. It is expected, but not yet mandated, that these threshold learning outcomes will be used by Australian academics to design and align their ICT curricula and by accreditation bodies to measure against.

In anticipation of future regulatory constraints, this paper proactively attempts to assess the Network and Systems Computing degree at Victoria University with respect to the published threshold teaching and learning outcomes. This paper highlights the difficulty in applying these outcomes.

Keywords: ICT education, ICT curricula, Learning and Teaching standards, national standards.

The Higher Education Standards Project

Recent reviews of the higher education sector identified the need for an independent national body to oversee all public and private higher education provisions (Australian Government, 2008). As a commodity, higher education in Australia generates over $19 billion US dollars in revenue and it creates over 100,000 onshore and offshore positions (Australian Government, 2011a). Given the industry's economic importance, in 2010 the Australian Government allocated funds to establish a new regulatory body, Tertiary Education Quality and Standards Agency (TEQSA) to take on the regulatory responsibilities previously done by the Australian Universities Quality Agency and various state and territories bodies (Diwell, 2012). The establishment of TEQSA was designed to bring all providers under the one umbrella and ensure consistency of standards within the entire higher education industry.

TEQSA has a dual mandate: firstly to ensure that minimum standards are met; and secondly, to promote best practice and quality assurance of all offerings, which range from diplomas, associate degrees, undergraduate to postgraduate awards. In 2012, TEQSA will commence compliance and quality assurance assessments of the performance of each higher education provider against a Higher Education Standards Framework. The Framework incorporates Provider Standards, Qualification Standards, Teaching and

Learning Standards, Information Standards and Research Standards (Australian Government, 2011b). The composition of these component standards has been decided through referencing precursor documents and long consultation within the sector. In particular, much discussion has centered on Teaching and Learning Standards and the need to evidence the acquisition of minimum standards for students (Blackwell, 2012; Mazzolini, 2011 & 2012).

Teaching and Learning Standards Framework

In preparation for the impending Teaching and Learning Standards evaluations, the Government set aside $2 million to fund the Learning and Teaching Academic Standards Project (LTAS). As a first step, LTAS commissioned eight broad discipline groups, one being Engineering and ICT, to consult with their discipline communities and determine minimum learning and teaching academic standards. Starting with the award level descriptors defined in the Australian Qualifications Framework (AQF), each discipline group was tasked with identification of threshold learning outcomes (TLO) that describe the minimum professional capabilities expected of a degree level graduate.

Engineering and ICT Standards

Throughout 2010, the Engineering and ICT discipline group consulted extensively with stakeholders: academics, industry professionals, accreditation bodies, students and graduates, in a variety of workshops and forums for their views and informed perspectives. Initial meetings established advisory and reference groups whose task was to identify the important issues concerning learning outcomes. Nationwide consultations followed with industry and academic stakeholders to refine the learning outcome domains, their components and possible measures. Further consultations occurred online as part of the distillation of threshold learning outcomes of the Engineering and ICT discipline. The process culminated with a final revision by the discipline group and the publication of Engineering and ICT Learning and Teaching Academic Standards Statement in December 2010 (Australian Learning &Teaching Council, 2010a & 2010b). The five outcome areas identified were: Needs, context and systems; Problem-solving and design; Abstraction and modeling; Coordination and communication; and, Self-management. These outcome areas are listed in Table 1, together with their respective rationales and the threshold knowledge and skills expected of graduates.

The recent publication of the Engineering and ICT Learning and Teaching Academic Standards Statement has stimulated much discussion. Typically, computing and information technology programs are designed and evaluated against recommendations of their professional bodies; in the United States, the Association for Computing Machinery/ Institute of Electrical and EM/IEEE IT Curriculum Model is used (Koohang et al., 2010). Currently in Australia, the quality assurance of an ICT program is indicated through its accreditation with the Australian Computer Society (ACS). The accreditation involves ensuring that content covers the Core Body of computing Knowledge (CBOK), and that there is a progression to advanced topics that scaffold on top of programming fundamentals and project management topics. To gain a Professional level accreditation with the Society, a program must contain minimum of one equivalent full time year of IT material, with at least one third of this material being studied at an advanced level to provide extra breadth and depth of IT knowledge (ACS, 2009; Tan, 2008).

To what degree will TEQSA adopt the broad outcome areas specified in Engineering and ICT Learning and Teaching Academic Standards Statement of Table 1 in their assessments of teaching and learning for quality and compliance in ICT programs? At the time of writing, the political process remains in doubt due to funding cuts to the implementing body, the Australian Learning and Teaching Council (ALTC) and its dissolution at the end of 2011. The original plan was to generate a repository of evidence-based advice on curriculum and academic standards and disseminate this information through an access portal with links to international best practice. However, this is yet to be realized (Australian Learning & Teaching Council, 2010b). Therefore, the guidance and detail that practitioners are currently seeking as to the meeting of minimum teaching and learning outcomes is lacking in Engineering and ICT discipline areas (Blakewell, 2012).

Table 1: Threshold learning outcome areas prescribed for Engineering and ICT graduates. This table is reproduced from the Engineering and ICT: Learning and Teaching Academic Standards Statement, December 2010, page 8.

Outcome areas	Rationale	Graduates will have the knowledge and skills to:
Needs, context and systems	Graduates must be able to recognise, understand and interpret socio-technical, economic and sustainability needs within the context of Engineering and ICT challenges. Systems thinking enables graduates to represent the individual components, interactions, risks and functionality of a complex system within its environment.	Identify, interpret and analyse *stakeholder needs, establish priorities* and the *goals, constraints and uncertainties* of the system (social, cultural, legislative, environmental, business etc.), using *systems thinking*, while recognising *ethical implications* of professional practice.
Problem-solving and design	Engineering and ICT practice focuses on problem-solving and design, whereby artefacts are conceived, created, modified, maintained and retired (lifecycle assessment). Graduates must have capabilities to apply theory and norms of practice to efficient, effective and sustainable problem solution.	Apply *problem solving, design and decision-making methodologies* to develop components, systems and/ or processes to meet specified requirements, including *innovative approaches* to synthesise alternative solutions, concepts and procedures, while demonstrating *information skills* and *research methods*.
Abstraction and modelling	Graduates must be able to model the structure and behaviour of real or virtual systems, components and processes. Decision-making is informed by these processes of abstraction, modelling, simulation and visualisation, underpinned by mathematics as well as basic and discipline sciences.	Apply *abstraction, mathematics and discipline fundamentals* to analysis, design and operation, using appropriate *computer software*, laboratory *equipment* and other *devices*, ensuring *model applicability, accuracy and limitations*.
Coordination and communication	Engineering and ICT practice involves the coordination of a range of disciplinary and interdisciplinary activities and the exercise of effective communication to arrive at problem and design solutions usually in team contexts.	*Communicate and coordinate* proficiently by listening, speaking, reading and writing English for professional practice, working as an *effective member* or *leader* of diverse teams, using basic tools and practices of formal *project management*.
Self-management	Graduates must have capabilities for self-organisation, self-review, personal development and lifelong learning.	Manage own time and processes effectively by *prioritising competing demands* to achieve *personal* and *team goals, with regular review* of personal *performance* as a primary means of *managing continuing professional development*.

Nonetheless, the overall intention of Government remains clear — to ensure that minimum academic standards are met and to monitor all Australian program offerings (Diwell, 2012; Mazzolini, 2012). Cognizant of the future TEQSA audits looming on the horizon, the authors have undertaken a preliminary analysis of the Bachelor of Information Technology (BIT) program at Victoria University, in Melbourne Australia. This paper is concerned with the teaching and learning opportunities afforded by the BIT and how these can be measured using the threshold learning outcomes (TLOs) for Engineering and ICT.

Our Course and its Rationale

The Bachelor of Information Technology (BIT) in Network and Systems Computing commenced in 2011 at Victoria University in Melbourne, Australia. The groundwork for the BIT design occurred prior to the Learning and Teaching Academic Standards Project (LTAS) investigation of discipline specific threshold outcome areas and it was developed in response to a growing market demand for graduates skilled in systems' administration with networking expertise. This demand is evidenced by the Australian Government's heavy investment in setting up the infrastructure of a National Broadband Network (NBN). The NBN is expected to ensure future jobs for appropriately trained networking professionals as signaled by the 5% increase in contractor employment opportunities in the ICT sector and research of online ICT employment opportunities conducted in early 2009 (Dang, 2009; Australian Government, 2011c).

In scoping the most suitable program structure and content, much research of stakeholder needs was undertaken including the commissioning of commercial market research, seeking advice from industry partners and surveying comparative academic offerings. Additionally, a professional skills gap was identified in that many IT programs do not prepare students sufficiently to cope with the practical challenges in current technologies adoption (Finkelstein & Hafner, 2002; Taft, 2007). Employers want graduates with technical knowledge, intellect and a willingness to learn. Research on employer satisfaction with graduate skills found that Information Technology graduates lack problem solving and business communication skills and it is widely recognized that computing undergraduate studies do not adequately prepare students for proficiency in the workforce where they need strong communication skills and business aptitude (Begal & Simon, 2008; DCITA, 2006; MMV, 2010; Van Der Vyver, 2009).

The BIT program comprises 24 units of study which are studied across 3 years. In defining the program content, 3 main areas of study were identified: Core, Support and Professional Development fields. The Core comprises the key content of networking knowledge. The Core is supported by units devoted to computer systems, programming and database systems which were identified as necessary to prepare students for the rigor of this material, as shown in Table 2. Importantly, the Support units together with the Professional Development units help develop skills necessary for professional practice as specified by the accreditation body. Examination of Table 2 shows that several units cover content in one specific area whilst others span material across more than one area of study. As a general pattern, first year units focus on the development of the Support topics and collectively they lay the foundation for the development of the Core area. Once sufficient knowledge has been gained, 2nd year units build up Core learning. In 3rd year, many units cover Core and Support areas, with consolidation of Professional Development skills. Further, to assist in closing the professional skills gap more effectively, the possibility of incorporating industry-based certifications within the program was investigated. The development team extensively surveyed and identified suitable industry certification courses to assist in providing the technical skills needed by graduates in the area of networks and systems computing. These skills include understanding and manipulation of computer network and communication requirements, network operating systems, routing and switching fundamentals, security, wireless, broadband and web technologies, virtual machines, and other advanced network technologies. Specifically, several Cisco certificates were found suitable in supporting the core area of Networks and Communications studies, whilst several Microsoft certificates matched both Core area and some of the Support units (Tan & Venables, 2010).

When the BIT program was designed, the structure was influenced significantly by two University policies: the Learning in the Workplace and Community Policy (LiWC) and the Graduate Capabilities (GC) Policy (Victoria University (2008a and 2008b). The LiWC Policy aims to provide an engaging context for student learning through a workplace and community focus and experiences. To underline the importance of this context, the LiWC Policy mandates the inclusion of a minimum of 25% of work-integrated learning in the content and assessments of all University program offerings. The incorporation of LiWC experiences in the BIT structure was seen as an opportunity to further underpin the Professional Development component and help to strengthen the preparedness of graduating students for life in industry.

Table 2: The areas of study and their component units of the Bachelor of Information Technology in Network and Systems Computing at Victoria University.

Year	Units of Study	Core Networking	Support Computer Systems, Programming and Database Systems	Professional Development
1	Introduction to Computer Systems			
	Programming Principles			
	Computer Network Concepts			
	Communication & Information Management			
	Web Design & Programming			
	Introduction to Systems Analysis & Databases			
	Computer Operating Systems			
	Introduction to the Computing Profession			
2	Security, Privacy & Ethics			
	Internetworking Technologies			
	Programming for Networks			
	Web-Based Systems Development			
	Multi-User Database Systems			
	Network Security			
	Wireless Networks			
	IT Project Management			
3	Server Administration & Maintenance			
	Active Directory Design & Management			
	Network Management			
	Computing Project Analysis & Design			
	Virtualization in Computing			
	Advanced Network Technologies			
	Small IT Business Development			
	Computing Project Development & Implementation			

Table 3: Alignment of Bachelor of IT units against the 6 Graduate Capabilities of Victoria University. Each column is titled with an abbreviation of its Graduate Capability with the full description is given in the text.

year	Units of Study	Victoria University Graduate Capabilities (GC)					
		1. Problem solve	2. Locate & critically evaluate	3. Communicate	4. Work autonomously	5. Social & environment	6.Career Development
1	Introduction to Computer Systems	Basic	Basic	Basic	Basic		
	Programming Principles	Basic	Basic		Basic		
	Computer Network Concepts	Basic	Basic	Basic	Basic	Basic	Basic
	Communication & Information Management	Basic	Basic	Basic	Basic	Basic	Basic
	Web Design & Programming	Basic	Basic		Basic		
	Introduction to Systems Analysis & Databases	Basic	Basic	Basic	Basic	Basic	Basic
	Computer Operating Systems	Inter	Inter	Inter	Inter		
	Introduction to the Computing Profession	Basic	Basic	Basic	Basic	Basic	Basic
2	Security, Privacy & Ethics	Inter	Inter	Inter	Inter	Inter	Inter
	Internetworking Technologies	Inter	Inter	Inter	Inter	Inter	Inter
	Programming for Networks	Inter	Inter	Inter	Inter		
	Web-Based Systems Development	Inter	Inter	Inter	Inter		
	Multi-User Database Systems	Adv	Inter	Inter	Adv	Inter	Inter
	Network Security	Inter	Inter	Inter	Inter	Inter	
	Wireless Networks	Inter	Inter	Inter	Inter		Inter
	IT Project Management	Adv	Inter	Adv	Adv	Inter	
3	Server Administration & Maintenance	Adv	Adv	Adv	Adv		Adv
	Active Directory Design & Management	Adv	Adv		Adv	Adv	Adv
	Network Management	Adv	Adv	Adv	Adv		Adv
	Computing Project Analysis & Design	Adv	Adv	Adv	Adv	Adv	Adv
	Virtualization in Computing	Adv	Adv		Adv	Adv	Adv
	Advanced Network Technologies	Adv	Adv	Adv	Adv	Adv	Adv
	Small IT Business Development	Adv	Adv	Adv	Adv	Adv	Adv
	Computing Project Development & Implementation	Adv	Adv	Adv	Adv	Adv	Adv

As a further mechanism to support student learning and to enhance student employability, the University developed the GC Policy which requires that all programs progressively and incrementally develop lifelong learning skills. These skills are to be developed in addition and complementary to students' technical and field of study-specific knowledge. The GC Policy promotes the development of 6 generic skills that a graduate is able to do:

1. Problem solve in a range of settings;
2. Locate, critically evaluate, manage and use written, numerical and electronic information;
3. Communicate in a variety of contexts and modes;
4. Work both autonomously and collaboratively;
5. Work in an environmentally, socially and culturally responsible manner; and
6. Manage learning and career development opportunities.

These skills are known as Graduate Capabilities (GC).

More specifically, the GC Policy states that GCs must be progressively developed from a basic, through intermediate to advanced levels, and these levels can be seen mapped against BIT units of study in Table 3. Note the GC column headings for Table 3 are abbreviations for each of the GCs listed above.

An inspection of Table 3 shows that units of study vary in the number of Graduate Capabilities they cover. For example within the 1st year, the Programming Principles unit concentrates on the development of problem solving skills, locating and manipulating information, and working autonomously and collaboratively whilst the Introduction to the Computing Profession course undertakes a wider development of the GCs. Within the same year level, some units lend themselves to more advanced treatment as can be seen in Computer Operating Systems. Progressing from Year 1 to Year 3, the coverage of GCs becomes broader and deeper, reflecting the progressive development of these generic skills. This general pattern is also reflected in Table 2 where half of the 3rd year units span all 3 areas of study.

Importantly, the GC Policy allows for graduate capabilities development to be interpreted in the context of the relevant field of study. Thus the content and structure of the BIT program has been designed to ensure opportunities for graduates to develop their technical, professional as well as generic skills. This is reinforced through 2 final year capstone project units, where the real-world context of an ICT networking problem is solved by students necessitating the development and use of all generic and professional skill sets.

Measuring up to the ICT Teaching and Learning Standards

Given the likelihood that threshold learning outcomes (TLOs) for Engineering and ICT will be adopted in some form by TEQSA, a first cut inspection of the BIT against the published threshold outcomes of Table 1 has been made and shown in Table 4. This analysis was done in addition to the regular annual program monitoring mandated by the University, whose focus is on the overall effectiveness and viability of offerings. In Table 4, each unit is listed against the 5 major TLOs. The shading indicates where a TLO is supported in the unit outline and its assessment. A visual check of the table shows that 1st and 2nd year units typically cover only 2 or 3 threshold outcomes, whereas many of the 3rd year units encapsulate all of the TLOs. The 1st year introductory units collectively show a broad coverage of all TLOs. Examination of the 2nd year program shows a shift to higher level skills of problem solving, modeling and abstraction. In 3rd year, each unit covers a minimum of 3 TLOs, with many covering all. Note a shaded cell is indicative that a TLO is covered but the shading does not indicate the depth or extent of the coverage, nor does it indicate the level, basic, intermediate or advanced, nature of the material.

To evaluate the BIT program against the TLOs, a first insight can be gained by comparing Tables 2 and 4 where the shading patterns indicate some commonalities. Both tables show a collective spread across all columns in the 1st year, a concentration of units that develop technical and problem solving skills in the 2nd year followed by many 3rd year units which cover all columns. In part, these similarities can be explained by the correlation between the Professional Development column of Table 2 which can be mapped directly to the columns of Coordination & Communication and Self-Management in Table 4. Subsequent to this, there is only a loose correspondence between the remaining columns of Table 2 when compared with Table 4.

The lack of a direct one-to-one correspondence between Tables 2 and 4 is due mainly to the premise of their construction. Table 2 is devised to show where the content of individual units can contribute to the 3 areas of study within the BIT program. This is unlike Table 4, where the focus is on the acquisition of skill sets required. The loose visual parallel seen between tables can be partially explained by the notion of units covering specific content in Core and/or Support must foster the threshold learning outcomes of Needs, Context & Systems, Problem-Solving & Design and Abstraction & Modelling.

A better comparison can be made between Tables 3 and 4 since both tables were constructed around learning outcomes. However the characterization of the learning outcomes in each case is quite different. Table 3 looks at the generic skill set common to all graduates of Victoria University, irrespective of their discipline, while Table 4 learning outcomes are specific to Engineering and ICT cohorts. This comparison illuminates several commonalities and differences. Both tables show fewer learning outcomes being covered in the 1st year with a gradual buildup across the 2nd year. In both cases, there is a very broad coverage of columns in the 3rd year units as the emphasis of the BIT program is in realization of learning outcomes expected of a graduate within a workplace. However the number of learning outcomes covered in both tables is somewhat different. There appears to be more coverage of Graduate Capabilities than there is of the threshold learning outcomes. This can be explained in that the shading only indicates that development of a learning outcome is undertaken in a unit, rather than being indicative of the amount of coverage undertaken in the unit. The observed differences between both tables are due in part to the differing language used to describe generic and discipline-specific skill sets. Looking at the columns in Tables 3 and 4, there is no direct correspondence between any of the columns, nor is it possible to substitute a learning outcome in one table for one or several in the alternate.

Table 4: Alignment of Bachelor of IT units against the Outcome Areas identified by the Engineering & ICT

year	Units of Study	Needs, Context & Systems	Problem-Solving & Design	Abstraction & Modeling	Coordination & Communication	Self-Management
1	Introduction to Computer Systems					
	Programming Principles					
	Computer Network Concepts					
	Communication & Information Management					
	Web Design & Programming					
	Introduction to Systems Analysis & Databases					
	Computer Operating Systems					
	Introduction to the Computing Profession					
2	Security, Privacy & Ethics					
	Internetworking Technologies					
	Programming for Networks					
	Web-Based Systems Development					
	Multi-User Database Systems					
	Network Security					
	Wireless Networks					
	IT Project Management					
3	Server Administration & Maintenance					
	Active Directory Design & Management					
	Network Management					
	Computing Project Analysis & Design					
	Virtualization in Computing					
	Advanced Network Technologies					
	Small IT Business Development					
	Computing Project Development & Implementation					

Comments on the Yardstick

Victoria University continues to face the same local, national and international challenges as do other higher education providers of IT programs within Australia as it strives to maintain relevancy in its program offerings. So given the political climate, it makes sense to use the Engineering and ICT threshold learning outcomes to measure BIT program effectiveness as part of our review process. It is logical to use the TLOs as our yardstick since they are discipline-specific and therefore more likely to measure the learning outcomes recognized as desirable to graduates and industry.

The major difficulty in the application of TLOs is their lack of granularity as displayed in Table 4. In this table, there is no indication of the depth to which each learning outcome is developed, other than the year level of the component unit of study within the program. This is contrary to the information inherent in Table 3 where generic Graduate Capabilities are given as being developed to one of 3 levels: Basic, Intermediate and Advanced. There is an even greater imperative to have access to graded threshold learning outcomes:- to ensure that the BIT is eligible for Professional level accreditation with the Australian Computer Society, which specifies that at least one third of the program must be study at an advanced level of IT knowledge (ACS, 2009).

This attempt to assess the BIT program using the TLOs has highlighted this major concern with their application. Before we can truly evaluate our program, we need specific documentation and/or best practice exemplars that describe and illustrate each of the 5 fundamental TLOs. This documentation would need to break each threshold learning outcome into at least 3 incremental levels of skill and be supported by evidence of the types of activities and assessments that could achieve these levels of competencies. The original 2010 publication of Engineering and ICT Learning and Teaching Academic Standards Statement is deficient in this matter. Thus at the moment in the absence of new TEQSA requirements, it is especially important that learning outcomes are reported at staged levels for the current accreditation requirements.

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